



## NUCLEAR ENERGY

### Mission Statement

INEEL's Nuclear Energy (NE) Division provides science and engineering leadership in developing nuclear energy technologies that will ensure the availability of safe, affordable, secure, and environmentally-compatible sources of nuclear and nuclear-derived energy.

### Description

On July 15, 2002, the Secretary of Energy announced a major mission realignment that established the INEEL as the nation's leading center for nuclear energy research and development. Since then, the INEEL has transitioned from being a national laboratory primarily committed to environmental technologies and cleanup to one principally focused on the development of advanced reactor technology and nuclear fuel cycle issues.

As a reflection of this growing emphasis on nuclear research and development, FY-03 work volume in the NE Division will be approximately \$29 million, nearly 65% more than the previous fiscal year. Work volume in FY-04 is expected to increase to approximately \$50 million, a jump of more than 70%. In addition, the NE Division will execute a Laboratory Directed Research and Development (LDRD) project portfolio of \$2.8 million, and will administer \$1.2 million in Strategic Initiative Funding (SIF). Large fractions of these indirect-funded investments (86% of LDRD and 75% of SIF) will be dedicated to advancing the objectives of the Laboratory's Advanced Nuclear Energy Initiative while the remainder will be used to grow and maintain base business.



Although the NE Division's base business remains robust and diverse, with modest growth in a few selected areas, major growth in the division's programs has come primarily in the Generation IV, Advanced Fuel Cycle Initiative, and Next Generation Nuclear Plant areas. This trend is expected to continue through FY-04 and well beyond. Advanced Fuel Cycle work is expected to reach \$19 million; Generation IV R&D is expected to top \$5 million; and work related to the Next Generation Nuclear Plant



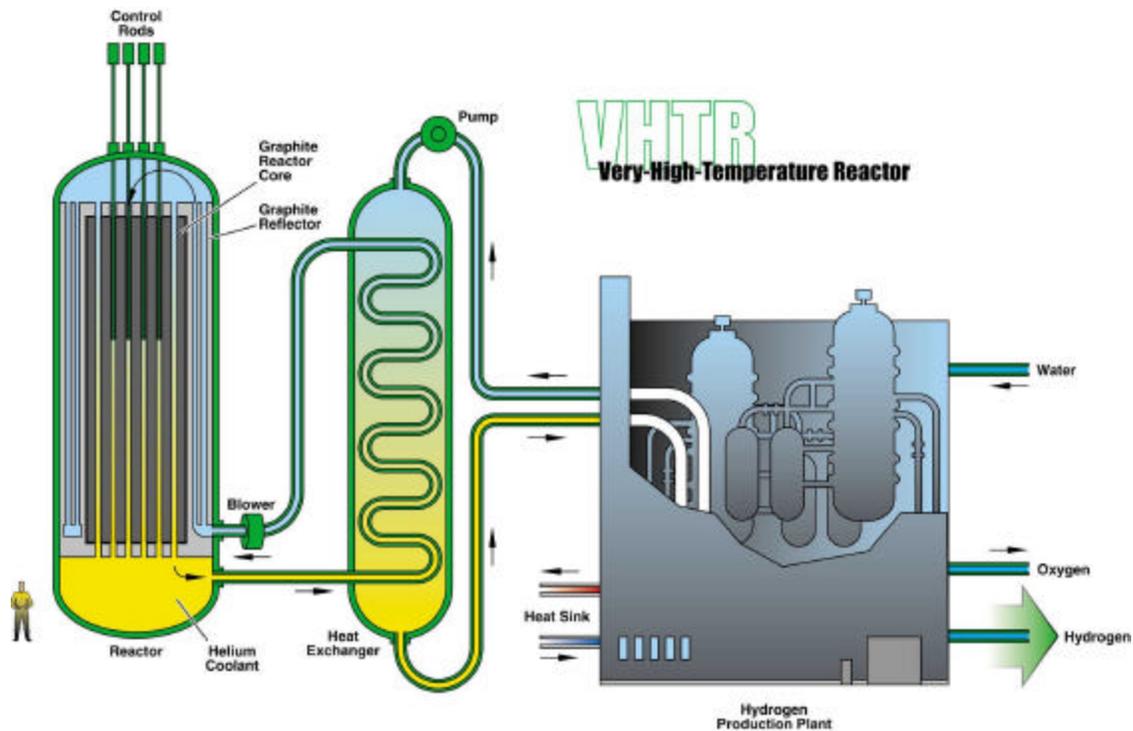
should reach at least \$10 million in FY-04. Work in the fusion safety area will be funded at the level of approximately \$2.2 million. Nuclear Energy Research Initiative (NERI) and International NERI work is expected to account for approximately \$2.9 million. The division will be responsible for the DOE's University Nuclear Fuels program, which represents a business volume of nearly \$3 million. Activities related to the development of a risk-informed, technology-neutral licensing and regulatory framework for advanced reactor designs should approach the \$1 million mark. Support for the Nuclear Regulatory Commission (NRC) will continue at the level of approximately \$5 million.

Because much of the NE Division's work scope and budget is not final until after DOE and other government agency budgets are set by Congress, only about one-third of the NE work scope is typically considered "firm" for planning purposes prior to the start of each fiscal year. For the purposes of this plan, the remaining "forecast work," which constitutes the majority of NE's work activity, is estimated based on best available information regarding projected budgets, DOE priorities, current activities in Congress, and the like. For this reason, substantial uncertainty exists regarding work scope, funding levels and distribution, and staffing needs. As noted in prior years, highly detailed long-term planning has limited value in this environment.

NE programs and projects are proposed to meet specific customer needs. We plan the scope, schedule, and budget for each program or project when it is awarded, commit to deliverables for each individual customer, and conduct the program or project according to customer requirements. In general, we report progress monthly to the customer on individual programs or projects.

### Advanced Nuclear Energy & Nuclear Science and Engineering

The Advanced Nuclear Energy Directorate and the Nuclear Science and Engineering Directorate will continue to support Advanced Nuclear Energy as well as nuclear base business in FY-04. The Advanced Nuclear Energy work is made up primarily of Generation IV R&D and R&D to support the Advanced Fuel Cycle Initiative. These programs support the development of advanced nuclear energy. The nuclear base business area includes the Fusion Safety Program, the Boron Neutron Capture Therapy Program, and smaller programs such as Space Nuclear, Applied Plasma Physics, and Thermal Science research programs. Specific areas of research include systems studies, reactor design, reactor physics, thermal hydraulics, nuclear fuels, and safety analysis that incorporates all of these areas. There is both experimental and analytical work, much of which supports the development of tools to analyze various systems.



**Fission and Fusion Systems.** The Fission and Fusion Systems department supports a systems-level analysis of fission and fusion energy systems. The INEEL has the lead on three of the six fission reactor designs identified as the highest priority to the U.S. in the Generation IV Roadmap—the Very High Temperature Reactor, the Gas Fast Reactor, and the Supercritical Water Reactor. The U.S. leaders for these programs are in this department, and they draw upon expertise in other departments in the Nuclear Energy branch as well as other branches of the INEEL. R&D for the U.S. work (including work done outside the INEEL) on these reactors is planned and coordinated by these leaders. This department will continue to lead these programs in FY-04. In addition to the fission work, this department also supports fusion safety work. The INEEL is the lead lab for fusion safety for the DOE fusion program. This includes experimental work focusing on mobilization of materials under accident conditions and analytic work, including modeling and code development to support safety assessments of fusion reactors.

Current and future business thrusts:

- Generation IV Reactor R&D Leadership
  - Very High Temperature Reactor
  - Gas Fast Reactor
  - Supercritical Water Reactor
- Fusion Safety
  - Support for the advanced fusion reactor concepts
  - Support for the International Thermonuclear Experimental Reactor
  - DOE/Monbuscho collaboration on molten salt for fusion reactors
- Space Nuclear
  - Support to industrial teams on the Jupiter Icy Moons Orbiter Project
  - Support to National Aeronautics and Space Administration (NASA) on the Jupiter Icy Moons Orbiter Project.



Molten salt/tritium chemistry pot experiment

**Fuels, Materials & Radiochemistry.** This department supports nuclear fuels development, understanding radiation effects on materials, and radiochemistry. Work is focused on development of nuclear fuel specifications and model development to predict and/or understand phenomena observed in postirradiation examination of fuels. Radiochemistry research supports separations chemistry, radiolysis chemistry, and tritium chemistry as well as environmental chemistry. This department works closely with the Irradiation Test Programs Department which conducts irradiations for fuel programs such as those under the Advanced Fuel Cycle Initiative and the Advanced Gas Reactor fuel program. These programs are primarily in support of the U.S. Generation IV program as well as the Advanced Fuel Cycle initiative.

Current and future business thrusts:

- TRISO Fuel Modeling
  - Advanced Gas Reactor Program

- Advanced Fuel Cycle Initiative
- International Nuclear Energy Research Initiative with the French
- Nuclear Energy Research Initiative with Oak Ridge National Laboratory
- Nuclear Materials Research
  - Nuclear Energy Research Initiative with Argonne National Laboratory
  - Lead bismuth corrosion
- Support to the Nuclear Regulatory Commission
  - TRISO fuels
- Fuel Specification Development
  - Advanced Gas Reactor Program
  - South African Pebble Bed Reactor



Photomicrograph of irradiated NP-MHTGR particle showing cracking in IPyC, OPyC and SiC layers

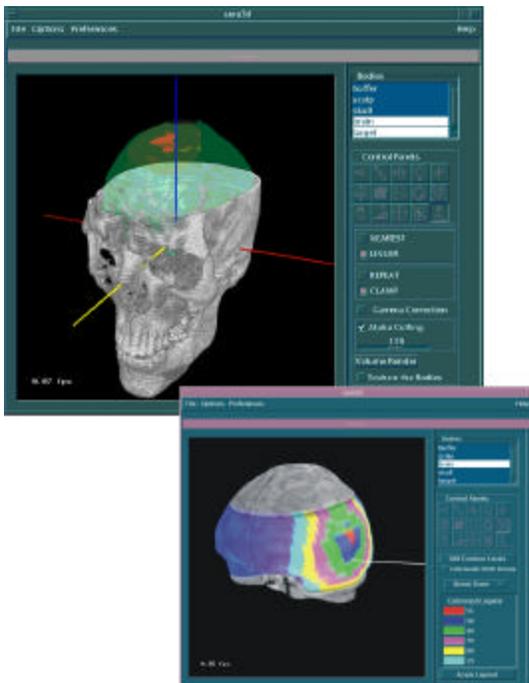
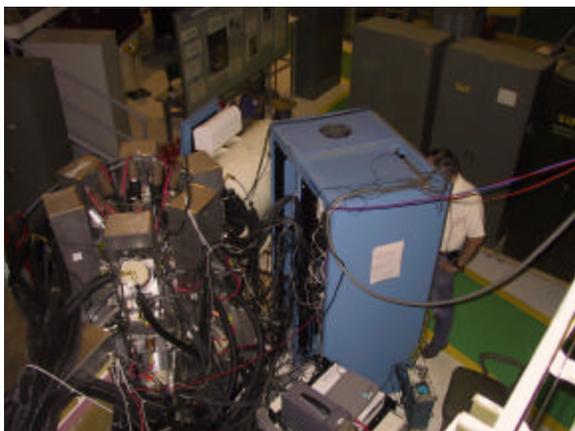


Image-based anatomical reconstruction for medical radiation dosimetry using the INEEL SERA software system

- Radiochemistry
  - Radiolysis chemistry
  - Tritium chemistry
  - Separations chemistry research for the Advanced Fuel Cycle Initiative
  - Environmental radiochemistry in support of the ICP.

***Nuclear and Radiological Sciences.*** In FY-04, the department will continue its broad-based R&D activities in computational and experimental reactor physics, nuclear physics, and radiation measurements, but with a marked shift in emphasis toward the needs of the new INEEL Program Secretarial Office, DOE-NE. While our traditional support of DOE's EM, SC, and NNSA programs will continue, the department will also have a much greater role in the DOE-NE Generation-IV, Advanced Fuel Cycle, and Next Generation Nuclear Plant programs, especially in the areas of applied nuclear science that support these key DOE initiatives. At the same time, we will continue our internationally-recognized collaborative activities in advanced medical applications of nuclear science and in integral benchmark data evaluation for ex-core nuclear criticality safety assurance applications,



Gamma and neutron detector array used for fundamental nuclear parameter measurements.

- Nuclear Physics and Radiochemistry
  - Differential nuclear data (cross section) measurements
  - Specialty radioisotope production
- Advanced Radiation Measurements
  - Nuclear assay systems
  - Advanced nuclear instrumentation
  - Ultrasonic and positron-based application for nondestructive evaluation/nondestructive assay
  - Computational and experimental medical radiation dosimetry
  - Collaborative medical radiobiology research.

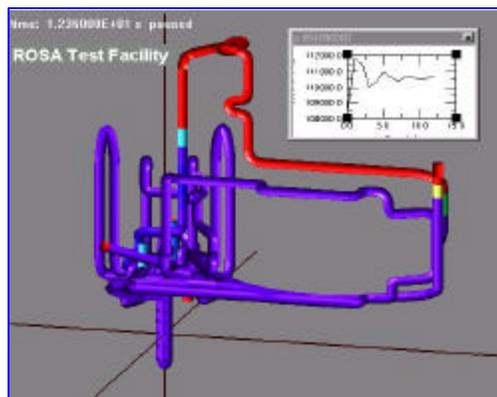
**Thermal Fluids.** In FY-04, the department's projects will span a wide variety of products and services, including development of the RELAP5-3D nuclear reactor systems computer code, adaptation of advanced light water reactor codes for use in Generation IV reactor designs, adaptation of computational fluid dynamics techniques to nuclear reactor systems, completion of an advanced graphical user interface (GUI), and basic experimental studies in heat transfer and fluid dynamics. The department will continue its successful efforts to link different codes together through the Parallel Virtual Machine (PVM) interface to allow more detailed calculations for reactor systems.

Heat transfer and fluid dynamic work will center on projects performed in the world's largest mixed index of refraction flow loop. The department will continue to sponsor the International RELAP5 Users Group.

with an expansion of the latter effort to include in-core integral benchmark evaluations pertinent to the DOE-NE mission.

Current and future business thrusts:

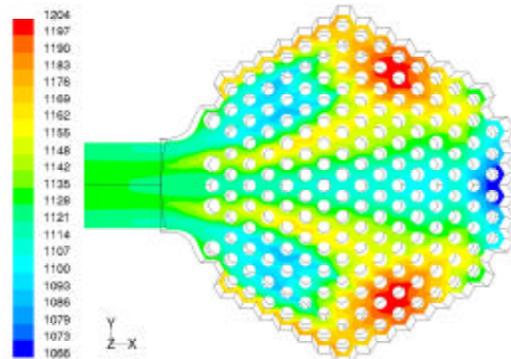
- Reactor Physics
  - Computational physics support for advanced reactor designs
  - Advanced Test Reactor experiment support
  - Nuclear criticality safety
  - Integral nuclear data evaluation and benchmarking
  - Research reactor and accelerator applications



GUI display of RELAP5-3D model

Current and future business thrusts:

- Systems Code Development
  - Update models, numerics, and programming language
  - Implement complete GUI functions into RELAP5-3D
  - Versions of all systems codes than will run under both UNIX and Windows operating systems
- Code Linkages
  - Seamless linkage of RELAP5-3D and computational fluid dynamics (CFD) codes, such as Fluent, using PVM
  - Link RELAP5-3D/Athena to current code sets
- Reactor Training Simulators
  - Increase capability and customers for RELAP5-RT
  - ITAAS plant training simulator in conjunction with IAEA
- International RELAP5 Users Group
  - Increase membership
  - Increased code capability for members
  - Code platforms availability
- Experimental Heat Transfer and Fluid Dynamics
  - Large-scale eddy simulation
  - Turbulence modeling
  - CFD code assessment.



GT-MHR lower plenum temperature profile calculated by Fluent.

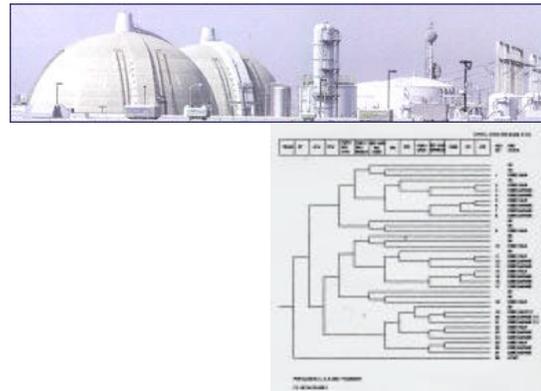
## Nuclear Safety and Regulatory Programs

The Nuclear Safety and Regulatory Programs Directorate is responsible for a wide variety of projects related to the safe uses of nuclear energy. During FY-04, the directorate will perform or support projects for the NRC, DOE, NASA, the Department of Defense, and other program sponsors. The Directorate will develop and apply methods and tools in the areas of probabilistic risk assessment, quantitative methods, trends and patterns in nuclear events, design and execution of irradiation test programs, and development and distribution of nuclear fuels for university and other research reactors.

The directorate is composed of two departments. The Risk, Reliability, and Regulatory Support Department performs probabilistic risk assessment and related work for the NRC and a variety of other program sponsors. The Irradiation Test Programs Department performs engineering analyses and safety analyses that are used in the execution of irradiation testing programs related to Generation IV, Advanced

Fuel Cycle, Space Nuclear, and other nuclear research and development programs. The activities of these departments are described below.

**Risk, Reliability and Regulatory Support.** In FY-04, the department will continue to play a major role in evaluating the safety of the nuclear industry. We will continue developing the standard risk models used throughout the NRC. That work has expanded to include low power and shutdown risk models. We are rapidly becoming the nuclear industry's central warehouse for the collection, coding, and processing of operational event data; we supply information to many major programs of the NRC. The department will continue to conduct research in risk assessment techniques and apply those techniques to state-of-the-art software tools. Our role in training the NRC in risk methods and tools will remain strong. We will build on our groundwork at NASA by providing risk tools and consultation on the Space Shuttle risk assessment and peer review and will position ourselves to assist in the implementation of the Columbia Accident Investigation Board recommendations. We will grow our involvement in the areas of infrastructure and homeland security, providing the risk and modeling expertise to the INEEL's National Security team.



Current and future business thrusts:

- Nuclear Risk
  - Probabilistic risk assessment modeling
  - Operational data collection and processing
  - Risk tools development
  - Risk training

Event tree for San Onofre Nuclear Generating Station



Space shuttle launch

- NASA Support
  - Risk assessment support
  - Risk tool development
  - Shuttle probabilistic risk assessment peer review committee
  - Space nuclear propulsion risk
  - Columbia Accident Investigation Recommendation implementation
- Advanced Reactor Licensing
  - Develop a technology-neutral, risk-informed and performance-based framework and guidelines
  - Identify the cornerstones of safety

- Train regulators on the advanced reactor technologies
- Evaluate potential safety concerns
- Infrastructure and National Security
  - Reliability of electric power
  - Threat assessment
  - Cyber security.

***Irradiation Test Programs.*** The newly created Irradiation Test Programs Department plays a key role in the planning, development, and execution of irradiation experiments for Generation IV, Advanced Fuel Cycle, Space Nuclear, and other nuclear energy research programs. The department is home to all safety analysis expertise that supports the Advanced Test Reactor. The department also manages DOE's University Fuels Program and is responsible for new business development for the Advanced Test Reactor.



Current and future business thrusts:

- Experimental design and execution in support of major U.S. nuclear R&D programs
  - Materials testing for advanced power reactor design
  - Irradiation of advanced fuel forms and materials
  - Irradiation testing in support of Advanced Fuel Cycle Initiative
  - Materials and fuels in support of space nuclear applications
- Safety analysis and other engineering expertise applied in support of Advanced Test Reactor operations.
- Materials irradiations for production of medical and industrial isotopes.
- Irradiation campaigns to support specialized research needs of international nuclear community.

## Projected Business Volume

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Major Business Area	FY-04 (\$M)
Advanced Fuel Cycle Initiative	\$19.4
Generation IV Reactor	5.0
Next Generation Nuclear Plant	10.0
Safety and Regulatory	8.8
University Fuels	2.9
Fusion Safety	2.2
Other	1.7
<b>Total</b>	<b>\$50.0M</b>

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